

THE VAMPIRE BAT

A PRESENTATION OF UNDESCRIBED HABITS AND REVIEW OF ITS HISTORY

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(Figs. 3-11; Plates V-VII incl.)

This article follows intensive studies of the Vampire Bat, *Desmodus rotundus*, during trips to Panama and Trinidad during 1933 and 1934, and observations of specimens in captivity from both areas. Between field reconnoiters, a thorough search of the literature has been made. The work has thus produced a quite complete history by bringing together recorded observations, references to studies of important pathogenic significance and notes of studies made by the authors. Thus collectively clad, the vampire assumes a more interesting and specialized form than past description has accorded it.

The studies of *Desmodus* outlined here were suggested to the senior author in the summer of 1932 during a collecting trip in Central America. The trip was concluded with a call upon Dr. Herbert C. Clark, Director of the Gorgas Memorial Laboratory in Panama. Dr. Clark told about his work with Dr. Lawrence H. Dunn in proving the Vampire Bat to be the carrier of a trypanosome existing in the blood of cattle, to which cattle were resistant, but fatal to equines. As cattle ranged in large numbers with horses and mules at night, and bats indiscriminately attacked both, the working out of remedial measures was a highly important problem.¹

¹ Summarized in the American Journal of Tropical Medicine. Vol. XIII, No. 3, May, 1933.

Several vampires were under observation at the Memorial Laboratory. They had been maintained for a number of months on a diet of blood obtained at a nearby slaughter house and defibrinated to keep it in fluid condition. Here was a demonstration of the practicability of maintaining this highly interesting species as an exhibit at the Zoological Park. Dr. Clark, however, could spare none of his specimens. All were needed to demonstrate the susceptibility of the vampire itself after biting infected cattle or being injected with the organisms. It was there indicated, and since proved, by Clark and Dunn, that after biting infected cattle, the bat continues its blood feasts night after night, but itself succumbs in a period of about 30 days.

The senior author decided to return to Panama the following summer and search the caves where vampires had been captured. Hence in August of 1933, accompanied by Arthur M. Greenhall, then a student at the University of Michigan, Panama was again visited and Dr. Clark provided guides to explore the Chilibrillo caves in the Chagres valley. We were informed that the caves were of limestone formation, with horizontal tunnels. In some parts these gave way to large chambers, from which again, other tunnels led into the mountain. We were equipped with headband lamps and batteries carried on our belts.

In a shack near the caves was an illustration of the frequency with which humans may be bitten by Vampire Bats. A boy about ten years old had been bitten five times during a week, and always on the under surface of his toes while he slept. He had bled profusely, and the earthen floor beneath his slatted bed was blood-stained each morning.

The route to the caves led through cattle trails in low, green tangle, with ankle-deep mud most of the way, as the period was the rainy season. There was a steep slope near the caves and a growth of rain-forest. The Panaman guides, pushing through barricades of vines, disclosed a hole in the ground. It appeared to be little more than the entrance to a coal chute. We slid in and found ourselves in a horizontal tunnel in which we could walk upright in single file. The tunnel soon grew wider and higher, the floor slippery with red mud. Through portions of this entering gallery there was swiftly flowing water, knee deep in places. It appeared to come through the sides, then to

seep through crevices in the floor. By pointing a light overhead, a double procession of big bats could be seen, the two streams flying in opposite directions.

After we had worked forward a fair fraction of a mile, the subterranean stream gave way again to the slippery floor. The hallway became larger and now showed side galleries. The guides stopped there to assemble the handles of the nets by which the bats were to be taken. The atmosphere was unlike that of caves in the temperate latitudes; the air was hot, heavy and sweetish, the latter condition resulting from the odor of thousands of bats. Common on the limestone walls were huge roaches, of pale, straw color. Another insect denizen, not apparent without search of nearby crevices, but possibly common enough, was a member of the hemiptera, of the genus *Triatoma*. This is a small, reddish, blood-sucking bug, coming under strong suspicion in recent studies of carrying the organism of Chagas fever, a disease produced by a trypanosome in human blood, diagnosed and discovered by Dr. Emilio Chagas. Here and there, in startling contrast on the walls, were spider-like creatures with a spread of limbs of five inches or more. These arthropods appear to be cave-dwelling members of the *Thelyphonidae*, to which the Whip Scorpion belongs.

We finally entered a big chamber, the arched ceiling of which appeared to rise about 50 feet. The ceiling looked smooth, yet it was rough enough to provide a hanging foothold for thousands of bats of several kinds. Each species hung in a cluster of its own, the smaller, insectivorous kinds and smaller fruit bats on the sides. Near the dome of the ceiling was a mass of spear-nosed bats (*Phyllostomus*), in a cluster about 15 feet in diameter. These bats have a wing spread of about 20 inches and bodies the size of a rat. Our lights disturbed them and caused a great shuffling of wings and movement of innumerable faces. There was considerable chattering from these larger bats, and their teeth showed plainly.

The side galleries were also full of bats and we inspected these in search of the big carnivorous *Phyllostomus* which could not be captured in the high chamber. We caught 18 and "fought" them into a mesh cage. All the while we were watching for vampires, which may be distinguished by their habit of running

along the vertical walls and darting into crevices to hide. In a deep side gallery we found bats of a kind not noted in the large chamber, but again no vampires. After several hours we retraced our way along the subterranean stream until, with a feeling of relief from the oppressive atmosphere, we saw a faint glow that showed we were close to the entrance of the cave.

After a breathing spell we sought and found the entrance to another cave shown on our chart. The route sloped easily toward a circular chamber fully 100 feet in diameter, though not more than eight feet high. Here were hundreds of bats hanging in clusters, and all of one kind—a medium-sized spear-nosed bat of a fruit-eating species. They were not timid and could be closely approached before they took flight. When a hand was waved close to them the result was a pouring of winged bodies from the ceiling until the air was filled. Again we made an unsuccessful search of the walls for vampires.

The third cavern had an almost vertical entrance through a well-like shaft. There was not room enough to get down with the nets. We lowered ourselves into the hole, reached a horizontal turn-off, and on flashing our lamps against the wall, saw several bats run like rodents along the vertical surface, then dart into crevices. We immediately identified them as vampires, but all escaped.

With lights turned out we waited a half hour, but the bats did not reappear. We explored another gallery and found a spot where a slender man might squeeze through. We were too fatigued to continue, however.

The only other passage sheered off at a ledge beneath which ran a channel of water, from wall to wall, which looked as if it were quite deep. There the day's reconnoiter ended.

The following morning we returned to the cave where the vampires had been seen and with much caution descended to the widened area, keeping the lights out and feeling our way. Ready with some small nets we had prepared the previous evening, we flashed the lights on the wall where the bats had been seen, but no vampires were anywhere in sight.

We reasoned that the vampires had retreated into the recesses of the tunnel with the deep water, or into the narrow shaft where only a slender man could get through. Greenhall

worked into this small, horizontal shaft and saw several vampires in a widened space ahead. He captured two and the others made their way into the tunnel with the deep water, which connected with a passage ahead.

Of the two vampires captured, one soon died. It was half grown and possibly had been injured in the net. The other, an adult female, lived for approximately four months after capture and, slightly more than three months after being caught, gave birth to a single vigorous infant. While as yet we do not know the period of gestation, the length of time from capture of the mother to birth of the young shows a surprisingly long period of pregnancy for such a small mammal.

After obtaining the female vampire, we left for the Atlantic side of the Canal Zone. Dr. Clark provided two quarts of defibrinated blood, fresh from the automatic refrigerator of his laboratory, but from that moment until we reached New York the vampire was a problem. We were naturally very keen to get it back alive. We were not worried about the 18 big carnivorous bats; they were feeding ravenously and fresh meat could be readily obtained. With an assortment of crates containing reptiles and amphibians, and cases of preserved specimens for the museums, we boarded a train for Colon. The defibrinated blood was in a package beside us, and the cage containing the vampire was swathed in black cloth. Dr. Clark had cautioned us to get the blood on ice again as soon as possible.

On the Atlantic side it was necessary for the senior author to stop two days at the Navy Submarine Base at Coco Solo to deliver several lectures. The commanding officer invited us to stay at his residence and here the defibrinated blood was placed on ice, while the bat was domiciled in the garage. That night some of the blood was measured out in a flat dish. The amount would have filled a fair-sized wine-glass. The bat hung head downward from the top of its cage when the dish was placed inside and would not come down to drink while we were there. Early the next morning we inspected the cage and found the dish nearly empty.

That routine never varied during the ten days' voyage to New York, with stops at Colombian ports. We never saw the bat drink the blood, but in the quiet of the night she took her meal.

At the Park the senior author decided to keep the vampire in the Reptile House where the temperature was automatically maintained and the atmosphere was damp, like a greenhouse. In roomy quarters she quickly settled down. Blood was defibrinated in the Park's research laboratory and the dish was never placed in the cage until dark. For several weeks, however, despite cautious inspections with a flashlight, no observations of her visits to the dish could be made, although at some time during the night the blood was consumed.

At last the vampire became tame enough to show a lively interest when the dish was placed in the cage. She would crawl down the mesh side a few steps, peer at the dish, then creep back to her favorite nook in a corner, where she would hang head downward, by one leg. Each night she came further down and wandered along the sides of the cage before retreating. Her deliberate motions were surprising: a slow stalk, head downward, and a retreat equally deliberate. Her subsequent actions added much to information gleaned from the history of the species.

When the blood had been set in the cage, the observer took his stand in what developed into a series of nightly vigils. Finally there came a night when the bat descended the side of the cage with her usual deliberation. Reaching the bottom, she started across the floor with wings so compactly held that they looked like slender forelimbs of a four-footed animal. Her rear limbs were directed downward. In this way her body was reared a full two inches from the floor. She looked like a big spider and her slow gait increased that effect. Her long thumbs were directed forward and outward, serving as feet. Anyone not knowing what she was would have been unlikely to suspect her of being a bat. In this trip to the dish it appeared that an unpublished habit of the vampire had been observed, and this, possibly, was the method the bat used for prowling over a sleeping victim in seeking a spot to use the highly perfected teeth in starting a flow of blood.

But other revelations were in store. Bending over the dish, the bat darted her tongue into the sanguineous meal. Her lips were never near the blood. The tongue was relatively long. It moved at the rate of about four darts a second. At the instant

of protrusion it was pinkish, but once in action it functioned so perfectly that a pulsating ribbon of blood spanned the gap between the surface of the fluid and the creature's lips. In 20 minutes nothing remained but a red ring at the bottom of the dish. The bat's body was so distended that it appeared spherical. She backed off from the dish, appeared to squat, then leap, and her wings spread like a flash. She left the floor and in a flying movement too quick for the eye to follow hooked a hind claw overhead and hung, head down, in her usual position of rest. Gorged and inverted, she preened herself like a cat, stopping occasionally to peer out of the cage in the light of the single, shielded lamp to which she had become accustomed.

Summarized, these observations appear to add much to the history of *Desmodus*. In less than half an hour it had been demonstrated that the vampire can assume a walking gait as agile as a four-legged animal; that the reason for its long thumb is its use as a foot on the wing stalk; that it is not a blood-sucking creature as has long been alleged; that it can gorge itself prodigiously and assume an inverted position to digest its meal.

The problem of recording these actions on motion picture film was at once considered. The outlook was doubtful. If the vampire had been hesitant about performing up to that evening in the illumination of a single, shielded light, it appeared that lights of enough actinic power for photography, yet tolerable upon the bat, would necessitate a slow introduction and increasing the strength of the lamps. The observer's plan was to build up the illumination, night after night, through a resistance coil, or dimmer.

Two weeks were spent in gradually increasing the strength of the light. Ultimately the bat tolerated three 500 watt bulbs, with a reflector. The scenes were exposed on 35 mm. panchromatic film. The lens employed was a 4-inch Zeiss, with long light-cone. Results were clear and satisfactory and the greater number of the illustrations accompanying this article are enlargements from the motion picture scenes.

Since contentions as to new habits, based upon a single specimen, are far more satisfactory if they are afterward substantiated by observations of additional individuals, it was determined that field observations should be continued and addi-

tional vampires obtained during the summer of 1934. Meanwhile the junior author started a search of the literature for observations other than the mere statement that the vampire is a "blood-sucking" animal. This search, conducted in the library of the University of Michigan, revealed an interesting continuity of inferences concerning habits, and some authentic observations.

Beginning with the earliest descriptions of the habits of the Vampire Bat, allegations point to a blood-sucking creature. This is seen in the writings of Aldrovandi, Shaw, Cuvier, Buffon, Geoffroy St. Hilaire, Swainson, Gervais, Hensel, Goeldi, Quelch and others. Recent writers such as Gadow,² Dugés³ and Herrera⁴ have indicated that the vampire applies its lips to the wound made by specialized teeth, in order to pick up the ensuing flow of blood.

Charles Darwin appears to have been the first scientist to observe a vampire in the act of drawing blood and note its procedure with satisfactory clarity. He secured a bat and definitely recorded the sanguineous habits of *Desmodus*. Previous to this, several larger species of bats had been under suspicion. Darwin's observation, however, did not change the belief that *Desmodus* was a blood-sucking type.⁵ Nor could anything to the contrary be found in comparatively recent writing until the publication of an article by Dr. Dunn, in 1932,⁶ containing the following:

"The vampire does not suck blood, as popularly believed, but takes it up with its tongue, seldom placing its mouth on the wound except when the latter is first made or when the bleeding is very slow. If the wound bleeds freely, the bat simply laps up the blood, hardly touching the tissues, while if the bleeding is scant the bat licks the wound."

Thus Dunn's observation, but a few years past, takes precedence, as far as could be found, in rectifying a long procession of erroneous inferences about the feeding habits of the vampire.

² Gadow, H., 1908. Through Southern Mexico. Witherby and Co., London, pp. 440-445.

³ Dugés, A., 1911. La Naturaleza Mexico. Ser. 3, T. I., Fasc. 2, pp. 1-4.

⁴ Herrera, A. L., 1911. La Naturaleza Mexico. Ser. 3, T. I., Fasc. 2, pp. 4-6.

⁵ Darwin, C., 1890. Naturalist's Voyage Round the World. John Murray, London.

⁶ Dunn, L. H., 1932. Journal of Preventive Medicine. Vol. 6, No. 5, pp. 415-424.

In further elucidation is a letter from Dr. Clark, dated April 18, 1934, and reading in part:

"Our vampire does not suck the blood. It uses its tongue to collect the blood, in a back and forth motion, rather than as a dog or cat laps up water and milk. I have seen them feed from the edge of cuts on horses, but, of course, never got close enough under these conditions to see the tongue in action. Animal feedings offered the bats under laboratory conditions establish the fact that they lick the blood."

As to the quadrupedal gait of the vampire, apparently the first mention of it is in the works of the Rev. J. G. Wood,⁷ who states that vampires can walk, rather than grovel like other bats, but the description is insufficient in indicating the habit.

Dr. William Beebe,⁸ in his book outlining experiences in British Guiana, states:

"We ascertained, however, that there was no truth in the belief that they (vampires) hovered or kept fanning with their wings . . . Now and then a small body touched the sheet for an instant, then, with a soft little tap, a vampire alighted on my chest.

"Slowly it crept forward, but I hardly felt the pushing of the feet and pulling of the thumbs as it crawled along. If I had been asleep, I should not have awakened."

Dr. Beebe's observation, though made in the dark, is good substantiation of the senior author's surmise about the soft gait of the bat in reconnoitering its prey. Dr. Beebe's description of the "pushing" of the feet and "pulling" with the thumbs does not however, define the actual action of the vampire, which *walks*, with body well elevated from the ground and the elongated thumbs used as feet.

In further substantiation of the observation that the bat has a walking gait, the senior author was informed by Sacha Siemel, an explorer of the Brazilian jungle, that while he was conducting a party close to the Bolivian frontier, a number of vampires attacked the horses. Mr. Siemel, with a flashlight, carefully noted the actions of the bats. Some he saw lapping blood from fresh wounds, while others, as yet undecided upon areas to bite,

⁷ Wood, J. G., 1869. *Illustrated Nat. Hist.*, pp. 116-118. G. Routledge & Sons, London.

⁸ Beebe, W., 1925. *Edge of the Jungle*, pp. 18-21. Garden City Pub. Co., New York.

stalked back and forth over the animals' backs, walked among the matted leaves of the forest floor, or hopped from one spot to another.

Observations during 1934: For the tropical reconnoiter of this year, the senior author planned a trip along the entire chain of the West Indies, terminating at its southerly end in collecting work in Trinidad and British Guiana. The junior author left a month ahead, on July 19, bearing a letter which put him in contact in Trinidad with Professor F. W. Urich of the Imperial College of Tropical Agriculture. Professor Urich he found engaged in an investigation, operating on a government grant, of the transmission of paralytic rabies by Vampire Bats. The disease was seriously prevalent among cattle and thus far fatal, although vaccine is now being administered to immunize the herds. The disease was also fatal to about 35 humans over a period of years. They were dwellers in the back areas where vampires are commonest, and the bat is not known to attack humans in the cities and towns.

Professor Urich and his field assistant, J. P. L. Wehekind, extended much aid in getting together a collection of various specimens for the Zoological Park and providing transportation to different parts of the island. Several days after arrival in Trinidad the junior author, accompanied by William Bridges, captured seven vampire bats in the Diego Martin cave.⁹

The newly captured bats were taken to the Government Stock Farm and placed in a small framework building with sides of wire screen. In this building was another vampire that had been under the observation of Professor Urich for about three months. He had studied its feeding habits on goats and fowls. This bat was tame enough to come down and feed while observers stood quietly in the room. Notes made by Professor Urich during the studies of himself and his field assistant appeared in the monthly reports of the Board of Agriculture of Trinidad and Tobago. From these, Professor Urich granted permission to quote as follows:

"May Report. (Observation on May 19, 1934). When I got there at 9:40 P.M., found the bat feeding on the left foot

⁹ For details of a month's collecting work in Trinidad and Demarara, note serial account by William Bridges, *N. Y. Sun*, July 30 to Sept. 12, 1934.

of the cock, about 1 inch below the spur. The bat does not suck the blood, but laps it. Bat fed for twelve minutes from the time I arrived, the cock standing absolutely still. Then the cock started to walk, the bat following along the ground, and fed again. The cock became restless and walked away. Then it went into a corner of the cage, on the ground." (Observation by Wehekind).

"June report. (Observation on June 27, 1934). Bat started feeding at 8:30 P.M. and finished at 8:40 P.M., being so gorged that he could scarcely fly. Bat dropped straight on goat and started to feed. No hovering." (Observation by Wehekind).

In a later report. "As the *Desmodus* fed readily in captivity on fowls or goats, Mr. Wehekind was able to ascertain the method of feeding of these bats on fowls. It is quite different as stated in some records, the principal features of which is that the bat does not hover around its victims, does not suck blood, and does a fair amount of walking around on the victim to secure a suitable place for feeding. This is carried out by making a narrow groove in the place selected and lapping up the blood as it exudes from the wound. The bat always returns to an old wound on the same animal on its daily feeding. All these observations were verified by me (F. W. Urich) on several occasions."

The junior author of the present review adds the following notes from observations made in the screened house where the bats were quartered:

"On Friday, August 3, 1934, at 6 P.M., Professor F. W. Urich and myself went to the Government Stock Farm to see the condition of the captive Vampire Bats. One male vampire has been under Professor Urich's observation since May 18. It is known as 'Tommy.' When we caught seven additional vampires, Tommy was placed in a cage by himself, as it was known that he was free from paralytic rabies. Professor Urich then attempted to feed Tommy with defibrinated blood. The bat was used to feeding upon goats and fowls that were introduced into the cage and evidently did not relish the diet of prepared blood in a small dish. It seems to have taken a small quantity, but we thought it best to release it with the others after the necessary quarantine.

"At the time we entered the bat cage we found that a goat had been placed inside for the other vampires to feed on. The goat had been freshly bitten, as I noted three open wounds, two on the left side of the neck and one on the right, from which blood was oozing.

"The goat was calm, standing in one corner and no bats were feeding when we entered. Tommy was released from his quarantine quarters, flew and attached himself by the hind foot on the screening of the house, about a foot and a half from the sill. The goat was standing not far away from the vampire. The bat remained hanging for about five minutes, the thumbs bracing the body, the wings folded close to the arms. After a short interval, the bat showed signs of movement. The head nodded; the lips were drawn back, exposing the large canines and protruding incisor teeth. The bat's gaze finally rested upon the goat. I was watching approximately four feet away from the bat and the goat was nearer to me. Slowly the bat moved down the screen, a deliberate stalk. The fore and hind feet were lifted high from the wiring and the body was well above the mesh. The bat stalked down and I noticed that the movement of the forearm in the stride was exceptionally slow, the wings folded tightly. From two to three minutes were required to traverse the distance from the original position to the sill. Upon arriving at the edge of the sill, the vampire hung from its hind feet and dangled over the edge into space. There, it remained for about two more minutes. The goat was still standing in the same position. Suddenly and silently the vampire launched itself into the air and lightly landed on the middle portion of the goat's back. There was still no movement on the part of the goat. I moved quietly forward until I was but two feet from the goat. Tommy stalked to the shoulder and neck regions of the animal. After a minute or so of searching, the bat buried its head close to the skin of the goat. There were a few up and down motions of the bat's head.¹⁰ The goat then took a few steps forward and turned its head to the right and the left. The bat drew itself up but continued the nodding motions. The goat walked around the room rather rapidly, the vampire hanging on and thus riding its host. The goat passed by me, then stopped, and I noticed that

¹⁰ The act of pushing aside the pelage and of biting.

blood was exuding from a small wound and the bat was lapping it with a rapid darting of the tongue. The goat started to walk again and passed under a sort of table, a board of which brushed heavily against the animal's back. The goat was, in fact, obliged to slightly lower itself to pass under. The vampire quickly scuttled down the shoulder of the goat to avoid being brushed off. When the goat cleared the table the bat as quickly returned to the wound and continued lapping. We then forced the goat to go back under the table several times, the bat dextrously avoiding being hit by dodging down the shoulder. The movement was very agile and reminded me somewhat of the behavior of a crab. The bat could move both forward, backward and sideways, but seemingly preferred head first.

"I then reached out my hand and succeeded in touching the vampire, which attempted to dodge. It did not, however, make any movement to fly. The goat by now was exceptionally restless and ran back and forth around the room. It was a timid animal and it was of us that it was afraid. When we left, the bat was still riding the goat."

Later visits to the enclosure showed some of the other bats flying down from the ceiling, landing on "all fours" upon the floor, then hopping like toads from one spot to another, instead of assuming the walking gait. On one occasion a bat was seen to be so gorged and heavy from its sanguineous meal that it slid off the back of a goat to the floor. It was unable to launch itself in flight from the floor, hence climbed the wall, with head inverted, and when midway up launched itself in flight, returning to its customary hanging place on a ceiling beam.

When the senior author arrived in Trinidad, he spent considerable time observing the bats during the early evening, in the screened room. His notes on feeding actions would be nothing more than repetition of what has already been brought out. What he noted particularly, was the general tolerance of the goat to bats which crawled over its back or even wandered up the neck to the head. For a time after alighting on a goat, the vampire was not inclined to bite, but rested on the dorsal area, a bit forward of the shoulder, or clung to the side, where it looked like a big spider. This latter position is shown among the plates accompanying this article. The wandering of the bat upon the

strangely tolerant host, the occasional lifting of the bat's head, the leer that disclosed its keen teeth, and the observer's realization that all of this pointed to a sanguineous meal, produced a sinister and impressive effect.

When the wound had been made, the tongue of the bat seemed to move slower than when lapping blood from a dish, and was extended far enough to come well in contact with the tissue. Goats of the laboratory herd, which had been previously bitten while heavily haired, showed bare spot surrounding the area of former wounds. The wounds themselves had healed as a slightly indicated ridge, from three-sixteenths to a quarter of an inch in length, but the area devoid of hair was as large, or larger, than one's thumb nail. Apparently the hair had been shed in the area of the wound. Here may be a condition of "desensitization" in a vampire bite, with attending destruction of hair follicles. It has been suggested, though not with satisfactory evidence, that the saliva of the bat contains an anticoagulant, which might account for many bites bleeding for several hours. The term "desensitization," as here used, may be rather a loose one, but it signifies that something abnormal has happened to the tissue besides the opening of a mere wound by specialized and lancing incisor teeth. There can certainly be no injection of an anticoagulant, but there is a possibility of the application of some salivary secretion during the action of the bat's lapping tongue—a secretion retarding the formation of a clot about the wound. This matter will be considered in a treatment of physiological characteristics in following paragraphs relating to investigations now under way with four vampires in possession of the senior author.

Field observations in Trinidad indicated vampire bats to be fairly common, but not generally distributed. Near the base of the Aripo heights, particularly, frequent bites were reported. The bats attacked cattle, swine and poultry. Sows were bitten upon the teats and the wounds in healing so shrivelled these members that the animals were unable to nurse their young. Most fowls were unable to survive the loss of blood and were found dead in the morning.

Around a dish of defibrinated blood, the feeding motions of the four vampires brought back from Trinidad duplicated the

notes made upon the Panama specimen of the preceding year, though the latter represented a different subspecies. The animals so gorge themselves that their bodies become almost spherical. This gorging consumes from 20 to 25 minutes.

In some experiments with large fowls, weighing up to eight pounds, the bats were observed to be extremely cautious in their approach, slowly stalking in a circle wide enough to keep out of reach of the bird's bill. An action of that kind might readily kill a light-bodied bat. After several circular manoeuvres, an approach was made to the fowl's feet, the bat feeling its way forward, inch by inch, and finally nibbling gently at the under surface of the toe. This appeared to serve the purpose of getting the fowl accustomed to its toe being touched. If the fowl made an abrupt move, the bat would dart backward, then slowly stalk forward to resume its attack. Whether any slight "shaving" of the tissue was taking place and a salivary secretion was being applied by the tongue it was impossible to determine, as the bats were too timid to bear extremely close inspection. After these preliminaries, however, the mouth was rather slowly opened as if to gauge precisely the sweep of the incisor teeth, and then there was a quick and positive bite. While it has been customary to allege the utter painlessness of vampire bites, in several instances where fowls were under observation, there was a decided reaction of motion on the birds' part, showing that the bite was sharply felt. If the fowl moved, the bat darted back, but immediately returned to the wound, now freely bleeding. From this point the bat continued its meal and the fowl paid no further attention to it.

Physiology: Desmodus is no larger than the larger insectivorous bats. A particularly good female example of *D. rotundus rotundus*, from Brazil, shows a length of body of four inches and a wing spread of 13 inches.

The incisor teeth are extremely sharp and have a curvature that forms a scoop-like mechanism. The incisors are well in advance of the canines. The lower incisors are widely separated, forming a partial channel for the darting motion of the tongue in taking up blood from a wound. Examination of bites shows a crater-like wound. The sharp upper canines, being set far behind the incisors, appear to play little part in most wounds.



Fig. 3. Head of Vampire Bat, *Desmodus rotundus murinus* Wagner. The specialized dentition includes sharp upper incisors for lancing and inducing a flow of blood, the crowding backward of the upper canines, and separation of the lower incisors to form a channel for the narrow and elongate tongue.

Experiences of reliable observers point to a remarkable painlessness of the average vampire bite. There are statements that victims knew nothing of the attack, and would have remained ignorant of such a happening had they not found blood stains the following morning. An expedition from the University of Michigan in Santa Marta, Colombia, may be cited:¹¹

"We did sleep, but so soundly that it was not until morning that we discovered that we had been raided during the night by Vampire Bats, and the whole party was covered with blood stains from the many bites of these bats. It may seem unreasonable to the uninitiated that we could have been thus bitten and not be disturbed in our sleep, but the fact is that there is no pain produced at the time of the bite, nor indeed for some hours afterward."

In a previous paragraph it has been noted that a fowl introduced into a cage with vampires, flinched upon being bitten, this observation being made by the senior author. Examining some of the recent studies of Dunn it appears that the younger bats are not so expert in effecting their bites and that experimenters

¹¹ Ruthven, A. G. 1922. Misc. Publ. Mus. Zool., U. of M. No. 8, p. 10.

PLATE V



Fig. 4 (Upper). Spear-nosed Bat, *Phyllostomus hastatus panamensis* Allen. This is the position assumed by the greater number of bats in traversing horizontal surfaces. Such bats, when seeking to fly, usually ascend a vertical surface, in inverted position, before taking wing.

Fig. 5 (Center). Vampire Bat, *Desmodus rotundus murinus* Wagner. The quadrupedal gait, with body well elevated from the ground, illustrates how the animal lightly stalks and manoeuvres over the body of its victim.

Fig. 6 (Lower). The position of the thumbs, turned outward and serving as padded feet on the wing stalks, illustrates the facility of the stalking gait. From this position, a Vampire Bat can leap upward and take flight.

testing the bites of various specimens upon the human forearm occasionally found bats that dealt decidedly painful bites.

There is controversy as to whether the bat carries an anti-coagulant in its saliva, introducing it into the freshly-made wound to keep it bleeding, or whether a specialized type of bite induces prolonged bleeding. Bier of the Biological Society of São Paulo, Brazil, experimented with extracts of the salivary glands of *Desmodus* and also with a species of *Phyllostomus*¹² (*P. hastatus*). His published results indicate that *Desmodus* possessed anticoagulating properties in its saliva, while the non-hematophagus bat's saliva was completely inactive. In October, 1934, Dr. Barry King of Columbia University began experiments with the four Vampire Bats now in the care of the senior author. This work points to an anticoagulant in the salivary secretion of *Desmodus*, but time and checking will be required to define its activity.

Although mosquitos, blood-sucking flies, ticks and lice have long been known to harbor disease organisms in their saliva, the Vampire Bat only recently came under suspicion. The work of Clark and Dunn at the Gorgas Memorial Laboratory has confirmed the guilt of the bat.¹³ These investigators demonstrated that *Desmodus rotundus murinus* is a vector of the equine disease "murrina," prevalent in Panama and produced by *Trypanosoma hippicum* Darling. It is interesting to note that the disease also proved to be fatal to all of the bats carrying the trypanosome, although they live long enough after becoming infected to produce grave damage.

While there have been statements that vampires appeared to be unable to endure a fast of not much more than 36 hours, Urich states that vampires can fast as long as three days. The senior author fasted four specimens for 48 hours, seemingly without harm.

As early as 1865 Huxley¹⁴ made a detailed study of the stomach of *Desmodus* and found that its extremely intestiform shape was apparently specialized for rapid assimilation. This, together with the specialized dentition and peculiar type of

¹² Bier O. G. 1932. C. R. Soc. Biol. Paris. Vol. 110, pp. 130-131.

¹³ Dunn, L. H. 1932. Journal Preventive Medicine. Vol. 6, No. 5, pp. 415-424. Clark and Dunn. 1933. Am. Jour. Trop. Medicine. Vol. 13, No. 3, pp. 274-281.

¹⁴ Huxley, T. H. 1865. Proc. Zool. Soc. London. pp. 386-390.

quadrupedal gait, make the vampire especially adapted to its sanguinary mode of living.

Tradition: The term Vampire originated long before civilized man's knowledge of a so-called blood-sucking bat. In later years the discovery of a sanguineous bat appears to have inspired elaboration of the tradition. This history has been traced by the junior author through approximately 200 titles, a partial bibliography of which appears at the end of the article. Surmise, theories and observations of various naturalists in building up the history of the Vampire Bat have also been searched, as well as scientific nomenclature.

The term Vampire is apparently of Slavonic origin and was first applied in eastern Europe to alleged blood-sucking, supernatural beings and persons abnormally endowed with hematoposia. The preternatural Vampire was supposed to be the soul of a dead person which left the interred body at night, in one of many forms, to suck the blood of sleeping persons and sometimes animals. Of the numerous shapes thought to be assumed by the Vampire, it is of interest to note that in early history the bat form was not mentioned. It later found its way into the legends, as brought out in Bram Stoker's "Dracula." The preferred form seems to have been the werewolf, dog, cat, horse, birds of various kinds, snakes and even inanimate things such as straw and white flame.

Superstition about blood-sucking forms has been widespread and of dateless origin. It was known in many ancient cultures of the Old World. The tendency of blood-sucking creatures to produce legends is to be noted among the Mayans even before the arrival of Cortez in the early Sixteenth century brought contact with Old World superstitions. In this case of New World exaggeration, there was a basis for it—the actual presence of sanguineous bats. Here was reverence of a blood-sucking bat god,¹⁵ undoubtedly founded on the existence of a sanguineous bat common in most of the Mavan areas of habitation. Then again, the return of Cortez's followers to Europe with tales of blood-sucking bats, founded on acquired knowledge of an actual blood-drinking creature, appears to have strengthened the superstitions of Europe. From chronological examination of the old

¹⁵ Mythology of All Races, 1930. Vol. XI, p. 177. Archeol. Inst. Amer.

PLATE VI



Fig. 7 (Upper). Vampire Bat, *Desmodus rotundus murinus* Wagner. The beginning of a nightly meal of defibrinated blood. The contents of the dish was consumed in slightly more than 20 minutes, being lapped up by the tongue.

Fig. 8 (Center). Completion of the meal, showing spherical distension of the body. The action of the tongue is shown.

Fig. 9 (Lower). Preparing to leap upward for flight; this is preceded by a slight bending of the limbs.

literature, it seems that it was not long after the return of the Spaniards that allegations appeared about blood-sucking habits of the bats of Europe, where no sanguivorous bats have ever occurred.

After the return of the early explorers from the New World tropics, a "Vampire" epidemic broke out in Europe about 1730,¹⁶ especially in the Slavonic countries. All sorts of works, scientific and philosophical, related incidents and cases of those unfortunate people who became afflicted with vampirism and sucked the blood of men and animals. Up to this time, although bats were associated with supernatural happenings, they were not associated with vampirism. Slowly the tradition of vampirism added the bat form to its list and later fiction, founded on vampirism, included allusion to bat wings, bat-like movements and the actual bat form as portrayed in the really classic "Dracula."¹⁷

Early naturalists visiting Central and South America arrived there with definite knowledge of a bat of some sort that fed upon blood. The exact bat was unknown. This led to various inferences. The ugliest and largest bats were thought to be the vampire. Actual observations of these early travellers, thrilled by the strange New World tropics, appear to be in the minority as compared to the acceptance of tales they heard, or their deductions from dead specimens. Hence, we find in the old records weird descriptions of vampires hovering over their sleeping victims, fanning them with their wings to induce profound sleep, inserting long tongues into a vein and sucking the man or beast dry.

Taxonomy: The actual vampire was accorded a place in the formal, binomial lists before it was individually known to be a sanguineous bat. Prince Maximilian Wied separated the vampire from the genus *Phyllostoma* of E. Geoffroy and placed it in a separate genus, *Desmodus*, with the specific name of *rufus* in 1826.¹⁸ This application of a new specific name in the removal of the vampire from *Phyllostoma* failed to hold, as Geoffroy had already established the species as *P. rotundum* in 1810.¹⁹ The

¹⁶ Encyclopaedia Britannica, 1910, 11th edit., Vol. 27, pp. 876-877.

¹⁷ Stoker, Bram. 1929. *Dracula*. Doubleday, Doran & Co., Inc., Garden City. N. Y.

¹⁸ Wied, M. 1826. *Beiträge zur Naturgesch. Braziliens*. Vol. 2. p. 231.

¹⁹ Geoffroy, E. 1810. *Ann. Mus. Hist. Nat.*, p. 181.

generic separation, however, was clearly indicated by the specialized dentition, although *Desmodus* still retained a place in the family of Spear-nosed Bats, *Phyllostomidae*. Waterhouse in 1839 referred to the vampire as *Desmodus d'orbigny*.²⁰ Wagner in 1840 proposed the specific name of *murinus*.²¹ To bring the taxonomy to date we quote from Osgood, 1912:²²

"In selecting specimens of *Desmodus* for comparison, I find a noticeable difference in size between examples of typical *D. rotundus* from Paraguay and specimens from Mexico and Central America. In typical *rotundus*, the forearm measures 60-64 mm., while in Mexican and Guatemalan specimens the maximum is 55. A corresponding difference is shown by the skulls. It would seem advisable, therefore, to recognize a northern subspecies, using Wagner's name *murinus* (Suppl. Schreb. Säugeth., I, p. 377, 1840) which would stand as *Desmodus rotundus murinus* Wagner."

It now appears that the only known sanguineous bats of the world occur in the American tropics, forming the family *Desmodontidae*. This is composed of three genera, each with a single species, as follows: *Desmodus rotundus rotundus* Geoffroy; *D. rotundus murinus* Wagner; *Diphylla centralis* Thomas, and *Diaemus youngi* (Jentink).

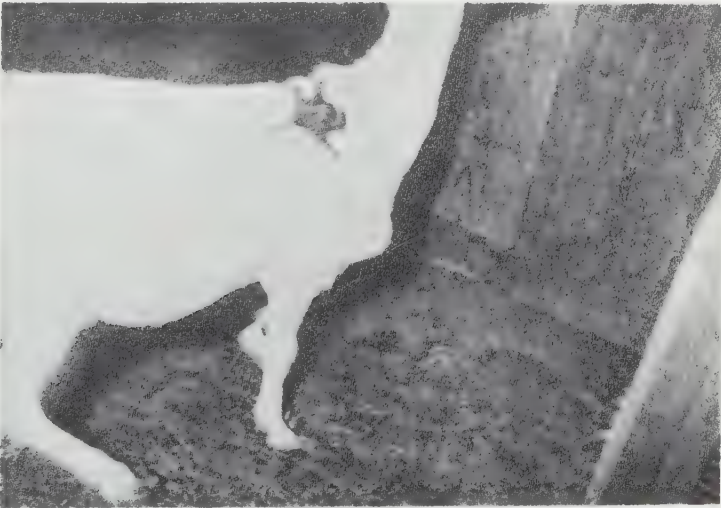
The habits of *Diaemus youngi*, appearing to be a rare species, have not as yet been authentically noted. The dentition, however, points to it being of similar habits to the two former sanguineous species.

²⁰ Waterhouse, G. R. 1839-42. Voyage of the Beagle, Mammalia, pp. 1-3.

²¹ Wagner. 1840. Schreber's Säugthiere, Suppl., Vol. I, p. 377.

²² Osgood, W. H. 1912. Field Mus. Nat. Hist., publ. 155, Zool. Ser., Vol. 10, p. 63.

PLATE VII



Figs. 10 and 11. Positions assumed by the Vampire Bat, *Desmodus rotundus murinus* Wagner, in clinging to an animal with thick pelage. The claws of the hind feet grasp the hairs of the victim's body and enable the bat to move nimbly over vertical surfaces.

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